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ABSTRACT

Research evidence on the effectiveness of various methods of teaching at the university level are reviewed. Evidence is presented in the following areas: the effect of class size; large group instruction techniques; individualized learning, independent study, and programmed instruction; lecturing versus other methods; and laboratory teaching. The evidence strongly suggests that the size of the class need not be a major factor in the effectiveness of teaching and that the instruction process can be individualized and learning can be done independently provided that the correct procedures are used. The evidence further suggests that there is no one best method that is most effective for all situations and all subjects. The method that is most effective is the one that is most appropriate to the particular objective, to the size of the group, to the background and achievement of the students, to the personality and skill of the lecturer, and to the preferences of both professors and students for the particular method being used. Arbitrary and specific direction of students is as bad as lack of any direction. The studies on laboratory teaching methods suggest that there are many new approaches that can and should replace teaching of the conventional laboratory-experiment type. Since independent activity by the student is the ultimate goal, this fact should influence all teaching efforts. (SC)

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EFFECTIVENESS OF TEACHING METHODS AT THE UNIVERSITY LEVEL

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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EFFECTIVENESS OF TEACHING METHODS AT THE UNIVERSITY LEVEL

D.V. CONNOR

Summary

In this Bulletin a review is made of the research evidence on various methods of teaching at the University level. The evidence strongly suggests that two obstacles can be overcome:-

1. The size of the class need not be a major factor in the effectiveness of teaching. There are methods and techniques for adequately coping with large numbers.

2. The instruction process can be individualised and learning can be done independently provided that the correct procedures are used.

The evidence further suggests that there is no one best method that is most effective for all situations and all subjects. The method that is most effective is the one that is most appropriate to the particular objective being sought, to the size of the group, to the background and achievement of the students, to the personality and skill of the lecturer and to the preferences of both lecturers and students for the particular method being used.

(1) INTRODUCTION :

(a) Definition :

For the purpose of this Bulletin, teaching methods will be defined broadly as "attempts by teaching staff of the University, in any subject-matter field, to present material, to utilise facilities, to adopt any kind of procedure, or employ any kind of device, with the aim of causing students to learn", rather than the narrower definition of specific instructional techniques.

(b) Scope & Scources :

The intention of the Bulletin is to present a survey of experimental evidence relating to the effectiveness of various methods of teaching at the university level. The list of studies cites samples rather than exhausts the available literature, the criterion for selection being the rigour of the experimental design. However,

reference is also made to broader survey-type studies and here the inferences made have yet to be checked. . The research reported comes mainly from the United States where experimental groups, "experimental classrooms" and even "experimental colleges" have been set up. Most of these projects have been sponsored and financed by the Fund for the Advancement of Education.

(c) Limitations :

It will be realised that experimentation in this complex area of human behaviour is extremely difficult because of the large number of interacting variables to be controlled. In the more delimited studies, the independent variables have been largely controlled by the "matching group" technique and the analysis of variance model. While this is the most promising of the research designs, it does leave uncontrolled some of the variables operating and this is often the reason for inconclusive results, or results where there are "no significant differences" between different teaching methods. However, even with these qualifications it is possible to gauge trends and often to get quite conclusive results, although the findings are often so specific that it is difficult to generalise.

(d) Need for this Survey :

With increasing numbers of students, there is an increasing need to keep present teaching procedures under constant observation. Since methods used to date may have been suitable for a set of circumstances different from the present, we need to question accepted procedures and to devise new methods to meet new conditions. For example, we need modifications that will on one hand allow us to cope with greater numbers and on the other to individualise the instructional process. In addition to this and in spite of rising numbers and shortage of good staff, we constantly need to improve the quality of learning and teaching.

On examining the research evidence, we find that some of our long held assumptions about teaching methods are not sustained. On the other hand, some of the long held assumptions that were thought to be challenged are indeed being sustained by recent evidence. For example, we have assumed that large numbers could not be taught as well as small numbers, that there is one best method of teaching a subject, that individual responsibility for study is attainable only by senior students, that instructor-directed teaching is bad for the student. A survey of the recent

evidence may assist in evaluating these and other aspects of the effectiveness of teaching methods.

(2) THE EVIDENCE :

The extent of the literature can be gauged by the fact that Hatch & Bennett (1960) report 500 studies on various phases of Higher Education published after 1955. More specifically, on university teaching methods in general and special fields, Eells (1957) gives a very extensive annotated bibliography revealing the vast amount of data available. From these and other sources, evidence will be presented in the following areas :-

(A) Class Size
(B) Large Group Instruction
(C) Individualising Learning, Independent Study and Programmed Instruction
(D) Lectures versus Other Methods, and
(E) Laboratory Teaching

(A) Class Size :

The hypothesis being evaluated here is that it does not matter whether students are taught in small groups or large groups. Hatch & Bennett (1960) review twelve studies where this hypothesis was evaluated. The following are some sample studies:

(i) Macomber, F.C. and Siegel, L. "Experimental Study in Instructional Procedures", Miami Univ., 1957.

Courses in Chemistry, Classics, Economics, French, Mathematics, Physics, etc., were taught in large (31 - 296 students) and small (16 - 30) student groups.

Conclusions :

"Acquisition of subject matter is not adversely affected by assignment to a large class rather than to a small control section."

"When achievement, defined as the ability to solve problems and think critically in the subject-area was investigated, it was found that large class instruction compared favourably with control instruction."

"Student motivation and interest in the specific subject matter is not significantly diminished in large classes."

"Students' attitudes toward large classes appear to be influenced not by size but by the content of the course and the ability of individual instructors to handle large groups."

(ii) Rohrer, J.H. "Large & Small Sections in College Classes" Journal of Higher Ed. Vol. 28, 1957, pp. 275-279

A course in Political Science met in large (309-332) and small (23-31) sections.

Conclusion :

"The amount of achievement, as measured by standardised tests and attitudes of students, varied as a function of the course instructor and not of size of class."

(iii) University of New Mexico :

"Program for the More Effective Utilisation of Teaching Resources." Report, 1957.

Courses in Accounting and English (192 v 30 students). English (47 v 11), Algebra (56 v 19 - 29).

Conclusion :

"Where class sections were determined to be comparable, ... results .... suggest that the instructor is a more important variable than class size per se"

(iv) Rensselaer Polytechnic Institute : "Toward More Effective Teaching at Rensselaer". Report No. 4, 1958.

Courses in Chemical Engineering, Mathematics, Metallurgy, Psychology, taught to large (64-65 students) and small (20) students.

Conclusion :

Seniors consistently perform as well in large single sections as in traditional small sections. When juniors are taught by a combination of large lectures and small discussion groups, their achievement is comparable to that attained under the small sectioning system.

DISCUSSION : Fleming (1958) in reviewing the literature on class size as a variable in the teaching situation, concludes that class size in itself seems unimportant under typical conditions and that the benefits of small classes are as yet largely undemonstrated in research. Again Hatch & Bennett (1960) are of the opinion that something other than size, namely the quality of the teaching (and learning) is the critical factor, at least in higher education.

Where no significant differences occur between experimental (large) and control (small) groups, the tendency is to conclude that large classes are equally as beneficial. This could be concluded only where such variables as the instructor, objectives attempted, and student backgrounds and abilities were properly matched. As this is not frequently done, nor

possible, further research is needed for a conclusive answer. One additional major point that arises in some researches on class size is that what the teacher is trying to attain with students in large groups is often different from what he is attempting in small groups. Therefore one can expect significant differences, depending upon the kind of achievement tested at the end of the experiment. If the criterion test is largely one of facts and information, it may favour one group, and if one of understandings and applications, it may favour the other. For example, McKeachie (1962) claims that where the evidence is in favour of large lecture groups, the criterion test is likely to be measuring the acquisition of facts rather than concept learning and problem solving skills.

However, the research surveyed seems, with the qualificiations made, to suggest that it is not so much the size of the class that counts but the nature of the thinking and activity that the students engage in during and after the teaching.

Finally, class size means something different in the United States from what it does in Australia. For example, in the United States classes of from 60-70 are considered relatively large, the norm being much smaller than in Australia. Therefore, any hypothesis about size of class would have to be evaluated in its own setting, or any generalisations from American data qualified if applied to the Australian setting.

(B) Teaching in Large Groups:

Because of increasing numbers of students, shortage of qualified staff and the fact that the size of the class is not the critical variable in teaching effectiveness, efforts have been made to evaluate procedures that cope with large numbers. The new medium of television has encouraged this and there is quite a number of projects on the use of instructional aids using films, television, broadcasting and even tape recorded lectures.

Schramm (1960) reports that 425 studies of adequate designs, controls and statistical treatment exist in which comparisons of instructional television and conventional classroom teaching are made.

The University of Miami studies reveal certain types of large groups instruction, including television and the use of graduate assistants. These methods are compared with conventional lectures

where the groups are carefully matched for ability. The television classes did as well in subject matter tests as those in which conventional instructional procedures were used. In tests of critical thinking, there were adverse results in only one of the T.V. groups. Student motivation and interest in the subject matter were not significantly greater in the conventional classes.

The following are additional sample studies using closed or open circuit television :-

(i) ULMER, G. & TILLOTSON, D.

"Teaching of Mathematics at College and University Level". Review of Ed. Res. 31, No. 3, pp. 314-322, 1961.

The aim was to bring as many mathematics students as possible under the instruction of master teachers by means of film and television. The general finding was that there is no significant difference between the achievement of the "video" and "non-video" groups.

(ii) , ERICKSON, C.G. & CHAUSOW, H.M. Chicago's T.V. College, Chicago Board of Education, 1960.

This is the final report of a three-year experiment in the teaching of English, Biology, Political Science and Mathematics by means of open circuit television. The conclusion was stated as follows :- "Classroom levels of instruction and student performance were maintained in these College courses"

(iii) In a very well controlled study by DREHAR & BEATTY (1958) at San Francisco State College, with General Education courses in English, Psychology and Social Science, students viewed the courses at home. The groups were matched and the variables controlled by the analysis of variance technique and subject matter tests were given to both experimental and control groups. There were no significant differences in the amount of knowledge gained by the two groups in any of the subjects.

(iv) SEIBERT, W.F. & HONIG, J.M. "A Study of Televised Laboratory Instruction" Department of Chemistry, Purdue Univ. 1959.

The topic treated was laboratory performance in Chemistry - the acquisition of knowledge and skills. Under the strictest possible experimental controls, no significant differences were found between the means and variances of the five Chemistry tests.

DISCUSSION : Because of the widespread finding of a lack of a significant difference between experimental (television) and control (conventional lecture) groups, there has been a tendency to conclude that teaching by television is at least as good as conventional lectures. Stated in this form, the implication is that television teaching has some

advantages in other respects - namely in subjects where the visual element looms large, or in bringing the best teachers to a very large student body. McKeachie (1962) claims that although there is a lack of statistical significance, the trend of the data favours "live" classes. This, he suggests, is because the criterion tests for both groups are predominantly verbal while television is essentially suited to demonstration by a visual method. Also, again, the instructor variable is not properly controlled in that some instructors "freeze" and others "blossom" before a T.V. camera. A general conclusion, however, is that teaching by television has a definite advantage as a technique for dealing with large numbers in science teaching where special demonstration techniques are required, and where the most efficient use can be made of increasingly limited resources in materials and talent.

(C) Independent Study :

An alternative to the method of coping with large numbers by means of "large group" techniques described above is that of encouraging students to become responsible for their own progress in programmes of "independent study". This is, at the same time, an effort to individualise the teaching and learning process.** The idea here is to cut down on the amount of formalised student-teaching contact hours and so achieve economy of resources. Teaching by this method is a timehonoured technique but it has lately received added impetus in order to solve problems of both quantity and quality of teaching and learning under increasing numbers.

The amount of research into Independent Study Programmes in the United States is very extensive. The Fund for the Advancement of Education lists 16 institutions (in the United States) experimenting in this field, and Hatch & Bennett (1960) survey 1,086 programmes in independent study currently being evaluated. Hatch (1960) describes the new Experimental College whose whole curricula are based on this movement. Bonthius & Davis (1957) reporting on the Wooster undergraduate instructional methods programme, give information on a "national" study involving 20 colleges.

Most evaluation studies have necessarily been of a survey type because whole courses have been initiated at once rather than as a partial

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** For another example of a move to individualise the teaching and learning situation, see Page 9.

programme involving matched groups. The criteria employed have been impressions both of staff and students as well as measures of achievement. Comparisons with previous efforts have been favourable ones and there is much enthusiasm for the new programmes. Some experimentation with properly matched groups has occurred at Oberlin, Antioch and Vanderbilt Colleges but the full import of these programmes has not yet been evaluated as they are long-term projects. In the judgement of Baskin (1961), these programmes have led to both an improvement in quality of performance as well as coping with increasing numbers more efficiently and effectively. McKeachie (1962) describes the Colorado studies as producing better problem-solvers and more successful applications to new materials.

Some examples of the more specific and delimited studies are as follows:-

(i) BECKER, S.L. & DALLINGER, C.A. "The Effect of Instructional Methods upon Achievement in Communication Skills". Speech Monographs, No. 27, 1960, pp. 70-76.

The aim was to maximise students' responsibility for their own training in a course on Communication Skills. The finding was that there was little difference in achievement and skills whether the students attended regular classroom lectures, viewed television or read source material.

(ii) GIUS, J A., BLOOMERS, P.J. & MEYERS, R.

"The Effect of Voluntary Versus Obligatory Textbook Assignments and Recitations on Learning Principles of Surgery". There was no significant difference in the material actually learned in surgery. The performance was the same whether the material was assigned or voluntary.

(iii) PARSONS, T.S., KETCHAM, W.A. & BEACH, L.R.

"Effect of varying Degrees of Student Interaction and Student-Teacher Contact in College Courses". Univ. of Michigan. Instructional Efficiency Research Program (1958) Experimental treatments were:-

(a) Conventional classroom instruction
(b) Autonomous instructionless small groups

The courses were Child Development, and Sociology.

Findings were that the "independent - no teacher contact" students scored highest in both subjects.

DISCUSSION : The conclusion on independent study in relation to the size of the class seems to be that lecturing either in large or small classes can be made to stimulate independent study. As Hatch & Bennett (1960)

point out, "The vehicle may have to be a large lecture class but it will also have to contrive to send individual students on intellectual errands". While the independent study approach is critical of the old "lecture" approach, it does not wish to abandon what is good in it. There is also a prevailing view that this approach is not a 'flash in the pan' but should be integral to - and a regular part of - the teaching programme and should embrace all levels from First Year to Graduates. Further, it must not be understood as an abandoning of the student to his own devices but must be approached with care and sophistication. A knowledge of the personal goals and objectives of each student is essential and major changes have to be made to the teaching process.

While this is demanding upon the teacher in the initial stages of the process, it does cut down later on formal class hours and the need for student contacts of a routine kind. The evidence is that students do not ask for more individual help than with conventional procedures. Further, in the kind of "problem oriented" approach used, the desire for and opportunity for "spoon feeding" is diminished. This changes the Staff role from a detailed routine one to a supervisory one and releases them for higher level academic activities and research.

PROGRAMMED INSTRUCTION :

A rather more technical and systematic approach to individualising learning has been termed "programmed instruction". Viewed as a teaching device, "programming" is an attempt to organise and arrange subject matter both logically and in accordance with evidence from learning theory, so that learning takes place more efficiently and effectively. The material is evenly and systematically graded in steps, and knowledge of results of the students' efforts is given immediately and frequently to both student and teacher during the course of the teaching itself. Teaching machines and programmes are perhaps best viewed as teaching aids of a particular and rather revolutionary kind. In the last four or five years, there has been an "explosion" in the research literature on programmed instruction but as yet evidence of a conclusive kind is not obtainable.

It would need a separate report in itself to survey and evaluate the literature, and for our present purpose it needs only to be mentioned in passing as a promising movement in more satisfactorily coping with some aspects of the teaching-learning process.

(D) "Lecture" Methods versus "Other" Methods :

Somewhat related to studies on "large groups" are those studies comparing the conventional lecture method and methods such as discussion or problem setting, irrespective of the class size. Another example is the instructor-centred (lecture) versus the student-centred (small group project) approach, and also the teacher-directed and the self-directed approach in teaching. These methods, other than lectures, are closely related to independent study programmes but not necessarily identical. They make use of tutorials and seminars and could also involve assignments, projects and field work.

(1) Lecture versus Discussion :

One of the earliest studies was that of Bone (1925), who found no difference between lecture and discussion technique on measures of immediate recall but found that the material was retained longer when discussion was used. Most of the subsequent studies confirm this. For example, Ruja, (1954) found that lectures are superior for subject-matter-mastery, and discussion for understanding and "intensive acquaintance", although Green (1950) in teaching two history groups defends lectures on all counts. Guetzkow (1954), comparing the subsequent performance of students taught by lecture and quiz methods and those taught by discussion, discovered a significantly greater proportion of the latter went on to major in their particular field. He concluded that while the lecture-quiz method, being highly structured, resulted in apparently immediate benefit, participation in discussion was one of the characteristics of the course that attracted students into their major field. A rather negative finding comes from Becker's (1958) study, where he concludes that, as measured by mid-term and final examinations, "it makes no difference which method is used". The only advantage he could see was that students preferred the discussion method.

This and other evidence suggests that there is no clear cut answer to the question of whether lecturing or teaching by discussion is better. Much depends on what one's teaching objective is - whether it is to organise and present subject matter succinctly, to survey a field, to develop particular concepts, to illustrate and apply, to master facts immediately, to get students actively involved, or to develop and stimulate long term interests. Further, many of the studies viewed do not seem to control adequately the preference that the lecturer or the students have for the particular method being used. This would make a difference to the performance of both instructor and student in the experiment.

Finally, in these studies the criterion test being used to evaluate the two methods is not equally sensitive to both. Therefore, it depends on what kind of test you use as to what kind of result you get. In view of this, it might be concluded that "didactive teaching" is better for some purposes that can be stated and evaluated, and "informal absorption" methods better for others of a different kind.

(2) Problem Setting Methods :

In so far as students become more responsible for carrying through the activities themselves, this method approaches closely to "independent study" programmes surveyed above. In this case, however, it is rather an approach or point of view that the lecturer adopts which is the characteristic factor-namely to increase teaching effectiveness by employing methods of student inquiry and scholarship. The following are some examples of these studies:-

DAWSON, M.D. "Lectures versus Problem Solving in Teaching Elementary Soil Science". Science Educat. Vol. 40, 1956, pp. 395-404.

This was an experiment conducted at Cornell University in the Agronomy Course (140 students). One group was taught conventionally (lecture) and the other by problem solving situations.

Results: The mean gain on recall of specific information (facts and principles) was the same but in all the recognised steps of problem solving, the students in the problem solving groups scored consistently higher.

NOVAK, J.D. "An Experimental Comparison of a Conventional and a Project Centred Method of Teaching a college Botany Course" Jnl. Exper. Ed. Vol. 26, no. 3 Mar. 1958, pp 217 - 230

A comparison was made between the conventional method employed by a large State University and a six week period devoted to project work which involved more rapid presentations.

Results : The project-centred method was found to be at least as effective as the conventional method in teaching Botanical facts and principles, even though the rate of presentation was more rapid.

ULMER, G. & TILLOTSON, D. "The Teaching of Mathematics at College and Univ. Level". Rev. of Ed. Res. 31, No.3, 1961, pp. 314 - 322.

One group was taught conventionally (by lecture) and the other with emphasis on student experience and discovery, the use of problem solving situations, discussion, and study guides in order to encourage them to

develop concepts of calculus for themselves.

Result : There was no significant difference between the groups in the solution of problems or mathematical skills but the experimental group showed a greater understanding of meanings.

In a problem oriented approach to studying Psychology, McKeachie and Hiler's (1954) experimental group made 42% fewer errors, Barnard's (1942) group did better on a measure of problem solving and scientific method & in Ahmann's (1949) study, although the experimental group did no better, the problem solving (laboratory) method was considered so desirable that it was incorporated into the first-year teaching programme.

While more objective analysis of the worth of the "problem" approach is needed, some of the carefully controlled experiments cited indicate that it is at least as good, and probably better than the more conventional approach of lecturing. When evidence from other work on critical thinking and creativity is added, the method commends itself highly. It is a method in which the student is encouraged to inquire into, rather than be instructed in, a particular topic, and it is a method which stimulates and caters for scholarly habits of independent study.

(3) Directed or Undirected Learning:

There has been some controversy about whether students learn better while depending on their own resources or whether they should get a fair amount of direction from their lecturers. This again is very relevant for the value of independent study. The hypothesis in a number of studies has been that "directed" learning is more effective than "undirected" learning. Most of the evidence supports this hypothesis. "Directed" here, however, means "the presentation of clues to guide students to successful discovery and applications" rather than direction of an arbitrary kind. "Undirected" means student self-direction almost amounting to neglect. As examples of typical experiments, both Corman's (1957) study ("The varying amounts of kinds of information needed as guidance in problem solving") and Craig's (1956) study ("Directed versus independent discovery of relationships") found that the group receiving the greater "direction" learned more. In relation to study habits and techniques, the result of Krumboltz & Farquhar's (1957) study in comparing the two approaches was that "student-centred" methods were less effective than "instructor-centred" ones.

While these are possibly obvious conclusions, they may seem to conflict with the evidence from "independent study" experiments. However, teacher "directed" should not be identified with teacher "dominated". Further, even in independent study, the teacher is very much "director" - a scholarly leader who influences and encourages and is far from uncommitted in observing the way his students react.

Referring in general again to "lecture" versus "other" alternative methods, it appears essential, according to the evidence, to teach according to the method which is most appropriate to the circumstances. Therefore, it is not so much a matter of "lecture" versus "other" methods but that one method is preferable to another depending upon the objective being sought. This is particularly so with "other" methods (than Lecturing) where the effectiveness depends upon the topic being dealt with, and the lecturers' and students' preferences for the method. On the other hand, it seems that formal lecturing might be reduced without great loss to anybody but that many find it difficult to break out of the established pattern.

(E) Methods in the Laboratory :

Studies of the effectiveness of teaching methods used in the laboratory overlap to a certain extent with those using the "problem oriented", and the "independent study" approaches. For example, Lucow & Anderson (1961) describe five studies in Biology and Chemistry where laboratory methods were designed to increase students' self-direction and independence.

There are three broad surveys of the experimental evidence in the field of laboratory teaching. Kruglak (1954), in reviewing studies on science classes refers to a summary of thirty-five studies aimed at the better utilisation of Science teaching resources. His main conclusion was that there were too many 'cook book' methods used, where the answers were known in advance and the student had no part in devising the methods of the experiments. In a survey of the literature, Frings & Hichar (1958) abhor the dearth of experimental evidence and the diversity of the findings that are reported. They also protest that most of the teaching procedures seem over concerned with content and not sufficiently with the scientific method.

Finally, Miles & Deventer's (1961) review of laboratory methods concludes that in many studies there is little difference in results between lecture courses and lecture plus laboratory courses. They imply that the reason for conflicting results is that it is not always specifically known what is being aimed at in laboratory courses, or if it is that these things are not adequately tested.

Examples of the different studies reviewed in the present report can be given under -

(a) General laboratory procedures
and
(b) The use of specific techniques

(a) General Laboratory Procedures :

In these experiments, the effect of the use of the lecture plus laboratory sessions, or no laboratory session, and different kinds of general laboratory sessions, are evaluated. For example White (1945) compared a "group laboratory" method and a "lecture-demonstration" method in a Materials of Engineering course and found the former superior. A demonstration method and a conventional or individual method in college Physics were compared by Kruglak (1952). The latter was found to be better for simple manipulative techniques and the former for solving problems. Frings & Hichar (1958) compared "regular" methods with the use of both unlabelled diagrams and living specimens in a General Zoology course. His conclusion was that one method was no better than the other but that it depended both on the instructor involved and on the interest and preference of the students for the particular method.

(b) Specific Laboratory Techniques :

Specific aspects of laboratory teaching dealt with in these studies are as follows :-

(a) Stimulating different kinds of thinking
(b) Promoting independence of working habits
(c) Providing practice in a scientific technique
(d) Providing for problem solving procedures in scientific method.
(e) Fostering the ability to apply principles to new situations.

Mason & Warrington (1954) used current scientific articles as a basis for laboratory procedures in order to foster the ability to think in the scientific method. This experimental group proved superior in every respect to the matched control group in which the acquisition of information was emphasised. In another study of the comparative effectiveness of two methods of presenting Physics principles and the ability of students to apply these to new situations, Miles & van Deventer (1961) found that the (control) method of stating the principle and then illustrating and applying it, was less effective in application of the principle to new situations than the (experimental) method of developing the principle by demonstration and analysis of applications.

A very well designed and controlled study of the above kind of inductive and deductive thinking in the laboratory was carried out by Lahti (1956). He compared -

(a) A method where analysing problems (experiments) into the steps needed to complete them (scientific method) was uppermost. The steps were described by the instructor, performed by the student, and difficulties were dealt with, and

(b) A method employing the "research" approach, emphasising assumptions, "open-mindedness", the isolation of important factors in the experiment, reasoning critically and making inferences about the experiment and then performing it to verify some of the hypotheses held.

Three different kinds of test were given :

(i) Interpretation of data

(ii) Design of experiment, and

(iii) Performance in the experiment

The conclusions were that the inductive-deductive method was best in terms of tests (i) and (ii) but not in (iii). This suggests that if you want students to perform particular experiments well (in a skill sense), method (a) is better but if you wish to develop ability to use the scientific method, then method (b) is better. Cotterell is of the opinion that the former method, namely teaching manipulative skills, is far too widespread in the teaching of Chemistry and is not the main objective of university teaching in Science.

Finally, Stone (1958) concludes that in order to promote maximum thinking and understanding, a good method is to use experiments to ask questions, to predict results, to seek answers and to explain discrepancies between predictions and conclusions.

If any generalisation can be made about the effectiveness of different teaching methods in the laboratory, it would be that no generalisations can be made. So much depends upon the particular purpose that one has in mind in adopting various laboratory procedures.

Although there is insufficient conclusive evidence as yet to prove it, it is evident on the general grounds of their desirability that the approaches adopted by Lahti (1956) and Stone (1958) above, where use is made of a "two-handed" inductive-deductive "inquiring" method, have much to commend them

3. SUMMARY AND CONCLUSIONS :

Reviewing the evidence as presented on the different teaching approaches mentioned in (A) to (E), and with the qualifications mentioned earlier about limitations of the research designs and the complexity of the behaviour being examined, the following statements could be made about the effectiveness of teaching methods:-

(a) Students can be taught in large groups equally as effectively as in small groups. Much depends on what is being attempted, and there are situations where a large group would be more efficient, effective and economical than a small group. The size of the group becomes relevant only when a procedure inappropriate to the size of the group is adopted. There are many teaching aids which can increase the size of the group without any loss of efficiency. Large groups can as frequently be used for special purposes as can small groups, without affecting the quality of the teaching or learning.

(b) The method of Lecturing is appropriate and even essential for dealing with large groups where the purpose is to present material in a systematic way, to raise principles, to effect a coverage of a topic and to stimulate interest and enthusiasm with the aim of launching students into independent study. When this method is extended to small groups or to objectives that can be attained efficiently and effectively by more informal procedures or by the students themselves, it becomes inappropriate.

(c) Discussions, seminars, tutorials and other "small group" methods are superior to lectures for consolidating and integrating information and concepts and for applying these concepts and principles to practice. The effectiveness of any one of these small group methods will depend largely on the preference of the instructor for the method and his skill in conducting it, and on the preference of the student for the method and the extent to which he capitalises on it subsequently.

(d) It is better if all teaching methods, whatever the size of the group, can take the form of a problem to be solved, involving the students continuously, and injecting some purpose into the procedure. This creates an "inquiring" point of view and is more likely to be carried over into subsequent activities. This is more demanding on both instructor and students but should characterise all courses and not only senior students.

(e) Arbitrary and specific direction of students is as bad as lack of any direction. Students need direction of a positive kind but not so much as to make them dependent on the instructor. The kind of direction involved here is the proper deployment of materials and facilities, and the stimulus and opportunity to use them. The instructor is not uncommitted but he is unencumbered by the kind of detail best handled by the student.

(f) Since independent activity by the student is the ultimate goal, this fact should influence all teaching efforts. It is equally the aim in educational procedures to individualise instruction. Both these objectives are being increasingly implemented by some teaching aids now coming to hand that cater for both very large groups and for the individual student.

(g) The studies on laboratory teaching methods suggest that there are many new approaches, as mentioned in (d) and (e) above, than can and should displace teaching of the conventional laboratory-experiment type. It also suggests that the methods should be more precisely tailored to the wide variety of specific objectives that are attainable there as well as to the general objectives that are usually achieved. The instructor can promote here what he began in the lecture and is in a strategic position to foster independent inquiry in an intensive way provided he has set the stage beforehand.

4. NEED FOR FURTHER RESEARCH.

The research reviewed in this Bulletin although controlled to the extent possible in this kind of work, must still be regarded as gross attempts only to achieve answers to complex questions. As such it will have to give way to more delimited and precisely controlled studies of students' thinking in different subject matter areas and the implications of this for teaching. For this reason, some of the conclusions and implications can only be regarded as tentative. However, much of the evidence is useful in supporting - or otherwise - the opinions of skilled instructors. Though less than perfect, this kind of evaluation should continue. Indeed it would be helpful if we could discourage some of the teaching that is carried out now under the illusion that it is the best method and encourage instructors to adopt the experimental approach themselves. It could not be any more detrimental to the students than what appears to be happening now.

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